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Pseudomonas aeruginosa: A Controlled Burn Pathogen?¹

A.T. McManus

US Army Institute of Surgical Research, Fort Sam Houston,
San Antonio, Tex., USA

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P. aeruginosa (PA) became a commonly reported burn patient isolate after the introduction of the first generation of modern antimicrobial agents. With today's knowledge of the natural and acquired mechanisms of resistance to agents such as the sulfonamides and penicillin, it seems obvious that *Pseudomonas* was a natural candidate for the niche initially occupied by group A beta-hemolytic streptococci and other susceptible gram-positive burn pathogens. This microbial evolution and the resulting clinical changes were first recognized at this and other burn care facilities in the late 1950s.

The early reports of a morbid condition resulting from invasion of burn wounds by PA were not universally accepted. This skepticism was met by experimental proof of the pathogenicity of this organism for burned hosts by fulfilling Koch's postulates in a burned rat model [3, 4]. By the mid-1960s, the occurrence and clinical significance of PA infection in burned patients was accepted and PA was recognized as the predominant worldwide agent causing fatal wound infections in burned patients.

The incidence and mortality associated with PA bacteremia at this burn center for the years 1959-1983 (5,882 admissions) has been reported [5]. That review showed PA, with an incidence of 10.3%, to be the most common organism causing gram-negative bacteremia. The mortality associated with this infection was 77% and this was 28% higher than the mortality predicted on the basis of the severity of injury in the infected patients [6].

¹ The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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Table 1. Characteristics of patients colonized with PA after the introduction of single-bed isolation (1983-1987)

Colonized/total patients ($\times 100$), %	26.5
Mean day of colonization after burn	25
Median day of colonization after burn	19
Mean age, years	34.3
Mean total burn, %	38.8
Mean third-degree burn, %	18.67
Mortality, %	21

These data were collected from patients in an open ward intensive care unit environment where, despite strict infection control practices, cross-contamination was often unavoidable. In 1982-1983 a new single-bed isolation intensive care unit (ICU) was built. The burn center remained open, using an open-bed ICU during construction. Prior to the opening of the new unit, an admission and staffing plan was designed to prevent the new cohort of admissions, in their early postburn phase, from contacting patients previously admitted to the older open bed area. During the transition from old to new patient populations, a characterized endemic *Pseudomonas* strain continued to be found in the older patient population. This strain was not documented in the inanimate environment but was associated with the patients of the original population. The strain was not transmitted to the new patients and disappeared with the discharge of the older patient group [7]. The opening of the new facility, which allowed single-bed isolation of intensive care burn patients, was also associated with a reduction in overall gram-negative infections [8].

In this report, the incidences of PA colonization and infection in the first 950 patients admitted (1983-1987) after the opening of the new ICU are presented. Colonization and infection data were prospectively collected using methods and definitions previously reported [7, 8]. The study population had a mean age of 30 years and a mean total burn of 27.4% body surface, including 11.8% full-thickness burn. Overall mortality was 21%.

PA was isolated from 252 of these patients. The characteristics of this group are presented in table 1. Of particular note is that the average day of colonization occurred in the 4th week postburn. The relative frequencies of sites of initial colonization are presented in figure 1. Examination of the strains isolated demonstrated no evidence of any accumulation of endemic serotypes or antibiotic resistances.

Control of *P. aeruginosa*

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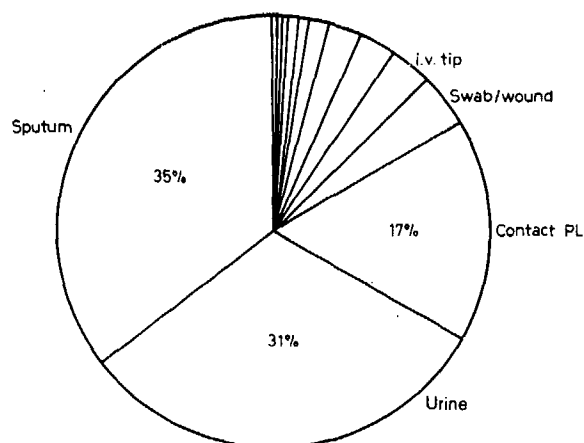
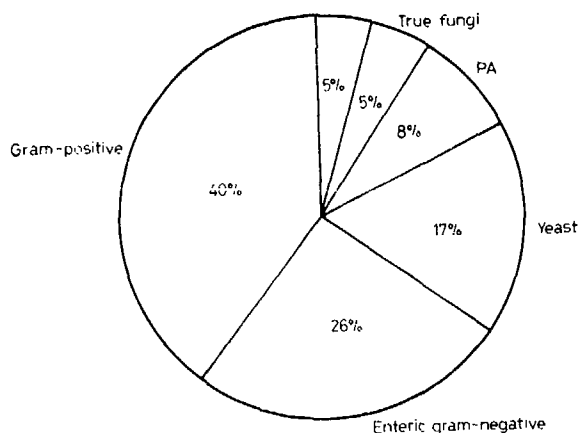


Fig. 1. Relative frequency of sites of initial isolation of PA in colonized burned patients. Unlabeled sectors represent groups comprising less than 4% incidence.



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Fig. 2. Relative frequency of organism types causing infections. Unlabeled sectors represent groups comprising less than 5% incidence, e.g. anaerobes, viral isolates.

Infections with PA occurred in 43 patients, an incidence of (43/950) 4.5% of admissions and (43/252) 17.2% of PA-colonized patients. These represented 8.6% of all infections. The relationship between PA infections and infections caused by other groups of organisms is presented in figure 2. A

Table 2. Characteristics of patients infected with PA after the introduction of single-bed isolation (1983-1987)

Infected/total patients ($\times 100$), %	4.5
PA infected/total infected patients ($\times 100$), %	17.2
Mean day of PA infection after burn	41
Median day of PA infection after burn	31
Total PA infections in 43 patients	55
PA infections/total infections ($\times 100$), %	8.6
Mean age, years	42
Mean total burn, %	52.6
Mean third-degree burn, %	29.9
Mortality, %	30.2

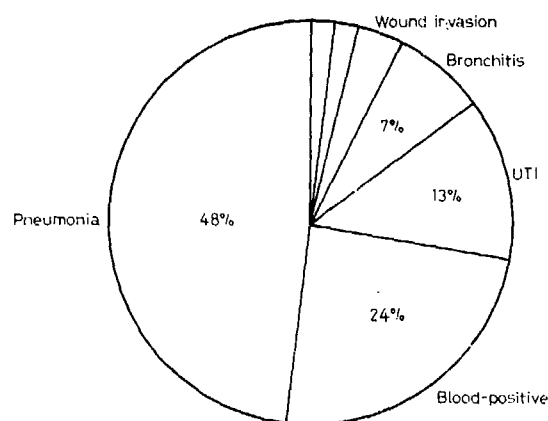


Fig. 3. Relative frequency of sites of PA infections. Unlabeled sectors represent groups with less than 4% incidence, e.g. eye infection.

total of 55 PA infections occurred in the 43 PA-infected patients, whose characteristics are presented in table 2. Single-site PA infections occurred in 32 patients; 10 patients had 2 infected sites and 1 had 3 sites of *Pseudomonas* infection. The relative frequencies of sites of infection are presented in figure 3. Pneumonia was the most common infection, followed by bacteremia.

A comparison of the incidences of bacteremia between the 950 patients admitted after the opening of the new ICU and the last 950 patients admitted to the old ward is presented in table 3. The incidence of bacteremia decreased from 8.1 to 1.4% after the introduction of single-bed isolation. As shown in

Table 3. Comparison of the frequency of PA bacteremia in the last 950 patients admitted to the older open ICU ward and the first 950 patients admitted to the new isolation ICU ward

	Positive	Negative	Total
Old ward	77	873	950
New ward	14	936	950

Chi square = 47.8; $p < 0.0001$.

Table 4. Comparison of mortality associated with PA bacteremia in the last 950 patients admitted to the older open ICU and the first 950 patients admitted to the new isolation ICU

	Died	Lived	Total
Old ward	58	19	77
New ward	6	8	14

Fisher exact test (2-tail), $p = 0.024$.

table 4, a second change observed between the two patient groups was a decrease in the mortality associated with *Pseudomonas* bacteremia. It is important to note that this decreased mortality associated with the newer ward was not a reflection of less severe injury. Using the method of Mason et al. [6] to define severity of injury, the new group had a mean severity of injury of 0.61, compared with a value of 0.58 in the old group. In conjunction with the decreased frequency of blood isolations, only two PA burn wound invasions occurred in the 950 new admissions, compared with the 23 patients in the older cohort. This is a significant decrease ($p < 0.001$) in this former hallmark of burn infection.

The incidence of colonization with PA does not appear to have been affected by the change in environment. In the year prior to the new ICU, patients had a PA colonization rate of 30%, a value quite similar to the mean of 26% observed in the new cohort. In the newer group of patients, however, only 17.2% of colonized patients had *Pseudomonas* infections, as compared to 86.6% of the colonized patients in 1982. The most likely explanation for this difference lies in the difference in the time of infection between the two

groups. The mean day of PA infection was 41 days in the new group as compared to 19 days in the 1982 patients. This difference is also reflected in the time of colonization in the new ICU, an average of 25 days postinjury, almost a week later than the 1982 group's average day of infection. The principal effect of isolation may be that it delays colonization which precludes exposure to PA during the interval of opportunity when open wounds and other sites are most susceptible to infection in burned patients.

In summary, in this burn center, PA infection appears to have arisen during the time of development and use of newer antibiotics and improvement of early resuscitative techniques, to have maintained its significance for more than 20 years, and then to have suddenly waned. The ebb in PA infection appears attributable, not to any radical improvement in chemotherapy or introduction of methods to inactivate virulence mechanisms, but to improved methods of patient isolation.

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Albert T. McManus, PhD, Chief, Microbiology Branch, US Army Institute of Surgical Research, Fort Sam Houston, San Antonio, TX 78234-5012 (USA)